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C3I Test Instrumentation System (Data Collection Subsystem): MANPRINT Findings

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C3I Test Instrumentation System (Data Collection Subsystem): MANPRINT Findings

Introduction

This paper presents MANPRINT findings pertaining to the prototype Command, Control, Communications, and Intelligence (C3I) Test Instrumentation System (C3I2). The findings, conveyed to Test and Experimentation Command (TEXCOM) for inclusion in their test report, were obtained during the TEXCOM government acceptance test of the C3I2 Data Collection Subsystem at Fort Sill Field Artillery Board during the week of 28 January 1990.

The prototype C3I2 is a computer-based data collection and analysis tool consisting of two major components, the Data Collection System (DCS) and the Data Reduction System (DRS). The DCS and DRS are mobile computer systems housed in separate S-710/M shelters mounted on M-880 trucks. The DCS and DRS will provide the capability for automated data collection and data analysis during operational evaluations of Army Tactical Command and Control Systems. The DCS will record real time digital and RF information from a system-under-test (AFATDS, ASAS, EPLRS, FAADS, MSE, TACFIRE, MCS, SINCGARS, and others). The DRS will accept data collected by the DCS, and provide the test officer in the field a near real time "quick-look" analysis to validate the progress of the test. Extensive posttest analysis of DRS data will be performed by the data analysis center of the testing organization.

C3I2 is being developed by Applied Research Laboratories (ARL), The University of Texas at Austin, in response to a required instrumentation capability document submitted by the Combined Arms Test Activity of the U.S. Army Training and Doctrine Command (TRADOC) in 1985. The TRADOC program manager is the Deputy Chief of Staff for Information, HQ TEXCOM. The tester is the Director, Battlefield Automation Test Directorate, HQ TEXCOM. The U.S. Army Research Institute (ARI), Fort Hood Field Unit, is conducting the MANPRINT evaluation of the system.

The purpose of the government acceptance test at Fort Sill was to attempt to qualify the system for participating, as data collection instrumentation, in the Initial Operational Test and Evaluation (IOTE) of the SINCGARS radio (integrated communications security model), scheduled for the April-June 1990 time frame. Participation in the SINCGARS test will constitute the first field trial of the prototype C3I2 in a real test situation. During that test, TACFIRE messages transmitted over the SINCGARS radio will be recorded by the DCS using both hardwire and radio receivers. The data will be passed to the DRS for reduction. ARI will continue to address C3I2 MANPRINT issues during that test.

During the Fort Sill acceptance test, the only two prototype DCS units available to date were exercised by the TACFIRE system located at the Board. (The DRS component is scheduled for acceptance evaluation at Fort Hood by TEXCOM during April 1990, prior to the SINCGARS IOTE.) Two contracted operators were assigned to each DCS, but actual operations were carried out by one operator at a time, the other acting as backup. A contracted system engineer was also on site to assist as needed, as was ARL, the system developer. ARI provided one observer for the test.

Unfortunately, the DCS failed the acceptance test because of a crucial software bug and three crucial MANPRINT findings. The latter were: (a) easy accidental reinitialization of the system by the operator; (b) inadequate presentation of system alerts to the operator; and (c) a possible safety hazard associated with vehicle instability. The developer has resolved the software bug and is currently working on the MANPRINT problems. The complete, detailed results are presented in this report in the format required for inclusion in the TEXCOM test report.

C3I Test Instrumentation System (Data Collection Subsystem):
MANPRINT Findings

(As submitted to TEXCOM for inclusion in the
DCS Government Acceptance Test Final Report)

Issue 4. Is there a MANPRINT concern that may have a significant negative impact on the C3I2 system in either training or operational environments?

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2.4.3 Results.

2.4.3.1 Manpower & personnel. The C3I2 system problems encountered during the acceptance test were address by contracted supervisory engineer personnel and the system developer, with the assistance of the contracted technician-operators. The technician-operators did not perform most corrective actions alone.

Impact: The technician's time is largely wasted at the operator's terminal. The use of contracted technicians (as opposed to enlisted military personnel) as system operators does not appear to be necessary, although it may be desirable for other reasons.

Comment/Suggestion: The basic requirement is that system problems be solved promptly. Meeting this requirement with the prototype system appears to require rapid access to personnel who possess an extensive knowledge of the system hardware and software--knowledge that the technician-operator may not be trained to provide. Because it is not feasible to require operators also to be system engineers, it may be advisable to make a clear distinction between system operation and system maintenance. The best division of labor may be to employ enlisted military personnel as operators while using the contracted technician and engineering personnel in the maintenance support function. This solution would free up the technicians, whose potential maintenance skills may be largely wasted in their current role as system operators. A maintenance team composed of the technicians and headed by the hardware and software experts would then be available to move from site to site as required, using other available time for system training or other constructive activities.

2.4.3.2 Training.

a. Training time. The prototype system is relatively easy to learn and operate despite the numerous MANPRINT findings presented in this report.

Impact: The time required to train system operators to perform C3I2 tasks (including not only C3I2 system interface tasks, but also the peripheral tasks necessary to support the external operational test) will not be extensive--probably less than one week for a person educated at the high school level.

Comment/Suggestion: This conclusion is tentative, and requires empirical validation. The training referred to does not include initial system setup (software installation, disk formatting, etc.) or system adjustment, repair, or maintenance. Additional personnel will be required for those purposes.

b. Training deficiencies. Although the test included no formal evaluation of operator training, several gaps in operator knowledge were noted. They are described below in paragraphs 2.4.3.2 b. (1)-(8).

Impact: The operator may not be able to take full advantage of the system's capabilities and documentation to efficiently solve operational problems encountered.

Comment/Suggestion: No formal training course has been developed for the C3I2 system operators or maintainers, although the developer has provided training and certain training and system documentation materials to the support contractor. It would seem advisable to require the completion of training materials, including complete reference and training manuals, programs of instruction, lessons plans, and training aids, all aimed at appropriate target audiences (system operators, maintainers, and software and hardware engineers) once decisions regarding manpower and personnel requirements have been made. Training on the C3I2 system should be formal and systematic.

(1) Electrical grounding. While the system documentation describes normal grounding procedures ("pound the ground stake into the earth about 2 feet"), no discussion of alternative methods is provided. Furthermore, as is the case with many systems, no method is provided for the operator to establish that a proper ground has been achieved.

Impact: In locations where it is not feasible to drive a grounding rod two feet into the ground, the likelihood of achieving a proper ground may be diminished.

Comment/Suggestion: System documentation should provide adequate discussion of grounding procedures for all situations likely to be encountered (e.g., parking lot locations). Alternatively, but less desirably, documentation could refer to other military documentation pertaining to grounding techniques. To the extent that grounding of the system is important, it should be stressed in training. Ideally, there should be a method for determining the adequacy of the ground.

(2) TK50 data archiving. One or more of the operators could not provide self-satisfactory answers to the following questions: (a) How would the system respond should an imminent condition of "tape full" arise? That is, would the system provide an alert? (b) What happens when a tape is removed and replaced with another? That is, does hard disk archiving continue where it left off with the previous tape or go all the way back to the beginning to archive all the data again? (c) What is the correct procedure for switching tapes during data collection? (d) What happens when the operator tries to shut down the system with normal shutdown procedures before all data have been archived? One operator was of the opinion that normal shutdown procedures could be concluded before all data were archived and that, as a consequence, unarchived data (on the hard disk) would be lost. The operator could not find information pertaining to this question in the documentation available to him after searching for approximately three minutes.

Impact: Incomplete or erroneous knowledge of the data archiving process could lead to mistakes in data collection, data handling, troubleshooting, and problem solving procedures; and although the system guards against loss of data, the operator may be led to perform operations conducive to data loss and inefficient or ineffective operations.

Comment/Suggestion: Complete knowledge of the data archiving process is essential to efficient, sustained operations without loss of data or operational efficiency. Additional training needs to be provided in this area, and documentation should be complete and easily referenced.

(3) Circuit breaker panel switches (see also finding 2.4.3.4 o.). An operator who was questioned about this panel was not familiar with the function of any of the switches. It is presumed that none of the operators had been trained in this subject.

Impact: Operator inability to use the panel effectively.

Comment/Suggestion: Ensure that all equipment that must be understood and used by operators is included in operator training and system documentation.

(4) Modem LEDs and labels. None of the system operators (or maintainers) knew the meaning of all rows of indictor lights on the modem panel. The eight rows have the following unexplained labels: TD, RD, DCD, CTS, RTS, DTR, DSR, and RI.

Impact: The labels are so cryptic as to be useless to the person who has not committed their meanings to memory. The operators knew the meaning of the first four rows of lights (although not necessarily the translation of the labels), but had only sketchy knowledge of the others. They constitute an operational and troubleshooting handicap.

Comment/Suggestion: All signals and labels should provide useful information to the operator; they should be fully explained and understood. Otherwise, they should be disabled and removed if it is feasible to do so.

(5) Computer panel display-control toggles. At least one of the operators was unfamiliar with the functions of the three toggle switches on the upper right-hand corner of the computer's front panel. Not all of these switches seem to be functional in the C3I2 system.

Impact: Operators may be unaware of the ability to switch the contents of the panel display.

Comment/Suggestion: These controls, as well as all others with which the operator should be familiar, should be illustrated, described, and discussed in system documentation; and their operation should be covered in training.

(6) Computer access door (see also finding 2.4.3.4 w.). The operators were not given guidance regarding the tightening of the computer door screws, nor when, exactly, the door must be closed for security reasons.

Impact: Possible breach of security.

Comment/Suggestion: Appropriate guidance should be provided in training, and the doctrine should be clearly detailed in system documentation. The operator needs to know the answers to questions such as, Is the shelter secure--regardless of whether the computer access door is closed--if the shelter door is closed?

(7) Power generator. The engines began to run rich after several days (see finding 2.4.3.4 b.). Operators were unaware of the cause of and solution to the problem.

Impact: Possible loss of reliable power.

Comment/Suggestion: Operators and maintainers should be trained avoid the problem by taking appropriate maintenance actions. The problem and its solution should be noted in system documentation.

(8) "ORIGIN" & "SENDER" (RUNTIME SYSTEM screen). One operator reported that the distinction between these two concepts had not been made during training. He did not know the difference.

Impact: Degradation of operational effectiveness.

Comment/Suggestion: The meaning of all software interface items should be made clear, both in training and in documentation.

c. Operator "checklist." There is no current listing of important tasks that should be performed during normal operations.

Impact: Operators may tend to forget to perform certain tasks that, while not critical to operations under many circumstances, could lead to serious consequences in unusual circumstances.

Comment/Suggestion: Place a short, but noticeable, list of important reminders on inside of the shelter door. The list should be located as high as possible on the door so that it will be noticed by the operator upon entering the shelter. The list should include topics such as grounding requirements (ground rod depth, etc.), the requirement to have CB13 in the off position prior to starting the generator, the advisability of operating with the computer panel lock in the locked position, and so on.

2.4.3.3 Human factors (operator software interface). Although the prototype software interface as a whole is not complex, it is somewhat inelegant in most of its features, and some procedures are more complicated than necessary. The CRT screens often include unnecessary items and verbiage, but they normally lead the operator through steps in a manner that minimizes error (although certain important errors can and do occur). The following list provides examples of interface findings noted to date.

a. System start-up procedure. The procedure requires unnecessary participation by the operator.

Impact: After the console's monitor automatically conducts its self test, the operator is presented the message "VT 320 OK." At this point, the operator must remember to press "Return," the letter "b" (for "boot"), and Return again. The operator is then prompted to enter the date and time, after which a series of messages that are not meaningful to the operator scroll by, ending with the message "System logged out," which may be misunderstood. Then the operator must press Return again and receive the messages "Welcome to Micro VMS 2.4.6" and "Username:" Here the operator must type in the enigmatic term "exedir," press Return, and ensure that a TK50 tape is in the tape drive.

Comment/Suggestion: The start-up procedures should be revised in a manner similar to the following. If the self test includes the keyboard, the message "VT 320 OK" should be expanded to say "VT 320 console OK. Press return key twice to boot system." If only the monitor is included in the self test, then the message should say "VT 320 monitor OK. . . ." (The two presses of the return key would allow the system supervisor or technician with knowledge of the appropriate command to intervene between returns for maintenance or troubleshooting operations. Other methods for accomplishing the same effect could be devised.) The screen should then remain blank (or, preferably, show a time filler to indicate that boot-up is taking place) until the date-time prompt

appears. When the date and time have been entered (without having to type in punctuation delimiters), the screen should return a message like "Please ensure that the TK50 tape is inserted in the tape drive if you wish data to be archived during data collection. Press `Return' to continue or F14 (EXIT) to quit." Upon pressing Return, the main menu should appear.

b. Validation of system functioning. There is no efficient, non-intrusive way for the operator to verify that the system is responding normally to an inactive external data environment.

Impact: If no "traffic" has been observed for a time, the operator may wonder if the system is working properly and be unable to make a conclusive test without interfering with ongoing data collection. (The impact of this problem would be expected to be minimal during a C3I2 system test because of the communication channels established for test control. The DCS operator is made aware of when and when not to expect data transmission. During a normal deployment of C3I2, however, such communication channels can be expected to be considerably less dependable or non-existent.)

Comment/Suggestion: Certain system features can provide relevant information to the operator: (a) The channel oscilloscopes might help the well-trained operator who can associate particular waveforms with particular emitters; (b) alert queues provided at the display reveal certain local DCS problems; (c) an internal, hardwired self-test loop indicates whether the DCS hardware is functioning appropriately, but would interfere with ongoing data collection activities. Some sort of non-intrusive, periodic means of system self-examination (for real time as well as posttest analysis) would be useful and should be considered in future development efforts.

c. Data archiving. According to the system developer, the F12 ARCHIVE DATA option does not actually cause data to be archived. Instead, it "prepares" the TK50 tape for dismount. The actual archiving process takes place only during the system shutdown procedure. Hence, the name of this option is a misnomer.

Impact: The system neither archives data periodically nor allows the operator to archive data at will. A hard disk failure prior to data archiving could mean the loss of test data. This is a serious shortcoming that needs to be addressed.

Comment/Suggestion: The system needs (a) to archive data automatically at regular intervals specifiable by the operator or system supervisor and (b) to allow discretionary archiving by the operator.

d. Cursor speed. The cursor does not respond quickly enough to keep up with a key repeat, producing cursor skid in certain

situations--as when the operator is erasing a line with a repeated backspace key.

Impact. Most operators will probably not notice. To those that do, it will be a minor irritation.

Comment/Suggestion. According to the developer, the problem results from slow processor speed, which is inherent in the system. The problem may disappear in the faster processors of future systems.

e. Speed of screen rewrites. Screen changes are slow and incremental. Parts of some screens are written horizontally (apparently resulting from the SMG screen management utility used).

Impact: The process of going from one "mode" to another; conducting necessary start-up, shutdown, and operating procedures; accessing help and utility screens; and so on, is relatively tedious compared with the speed to which today's computer users are accustomed. In a menu-driven program like this one, the operator accomplishes many functions by moving in and out of menus, which makes the slow response time especially noticeable.

Comment/Suggestion: The system developer notes that the speed of screen updates is determined by both the hardware and the screen management utility and is currently unavoidable for all practical purposes. As in the previous finding, the solution may lie in faster processors of future systems.

f. "Virtual" function keys. The system employs an operator interface technique involving what have been referred to as "virtual function keys," which are representations of keyboard function keys displayed on the operator's monitor.

Impact: This feature, which is in reality an ill-designed on-screen menu index, tends to slow down function selection unnecessarily, wastes screen space that could be better devoted to other information or blank space, and increases the probability that the operator will inadvertently press an incorrect function key. This menu index was probably directly responsible for at least two instances of inadvertent reinitialization of the front-end processors during the test. Operators were occasionally observed requiring excessive amounts of time (in the order of 2 to 4 seconds) just to determine which function key to press to select a desired menu item.

Comment/Suggestion: Any of a number of other selection devices for menus are available that would be a significant improvement over the "virtual" keys. Keyboard keys should be indicated on the screen, adjacent to the menu option, whether listed vertically or horizontally. An example of a horizontal menu would be: 1 **A**rchive; 2 **C**lear Alert; 3 **F**reeze; 4 **R**efresh;

5 Setup; 6 Utilities. This example would easily fit across the bottom of an 80-column screen. The cursor would default to one of the innocuous options in the menu (Freeze or Refresh). The "virtual" function key feature should be avoided in future developments. The system developer has discontinued use of the term "virtual function keys" (a term that is confusing to new operators), but, so far, not the feature itself.

g. "EXIT" & "HELP" options.

(1) Overemphasis of EXIT and HELP options. Most of the screen menus include EXIT and HELP as basic menu items that are given equal status (emphasis) with other menu selections that are much more likely to represent the sought-after functions.

Impact: The unnecessary and repetitive presentation of EXIT and HELP as basic menu items tends to make it more difficult for the operator to glean the appropriate information from the menu. It also reduces the amount of available screen space, which, in turn, may necessitate the creation of unnecessary and conceptually complicating sub-menus.

Comment/Suggestion: These two menu items need to be treated separately from the others. A menu should contain only those selections that are major operational options at the time the menu is displayed. The screen predominance of the EXIT and HELP items should be minimized by relegating them to the upper or lower screen corners, or by other means.

(2) "HELP" facility.

a. Non-utilization. Operators made essentially no use of the help screens during the test.

Impact: The help facility is wasted.

Comment/Suggestion: The latest versions of the help screens have not been evaluated to date. An earlier version of the facility was inadequate because many help screens were missing and those that existed provided little real help.

b. Mode selection "HELP" screen. The screen simply repeats information already provided by (or easily deduced from) the MODE SELECTION screen itself. Part of the wording is awkward: The explanation for the menu item "CONFIG CHANS" is "Prepare channel parameters for use," which indicates that the parameters are being prepared for use, rather than the channels.

Impact: The content of this help information is of little or no use. It wastes time.

Comment/Suggestion: In general, help screens should not be provided if the information presented does not give the operator significant additional information. A simple rehashing of

information already at hand is not useful. Such information wastes time and may be a source of frustration to operators.

h. Self test. This utility, still in the design stage, is limited. A "bug" was noted in the current prototype version.

Impact: At one point after the F11 SELF TEST option is selected, the operator cannot abort the self-test procedure even though a menu providing that option is presented.

Comment/Suggestion: While, according to the system developer, this problem may continue to exist in the prototype system, there are plans to devote considerable attention to further development of the self-test utility.

i. "SELF TEST UTILITY" screen. In preparation for conducting the self test, the operator is forced to proceed through this screen, which is essentially an unneeded help screen.

Impact: Entering the self test is more cumbersome and time consuming than it need be and gives the impression of being more complicated than it really is.

Comment/Suggestion: Such screens should be included in the optional help facility rather than as a part of the required operational sequence.

j. "DATA COLLECTION SYSTEM" main menu screen. It is possible that the operator will select "New" by accident, rather than "Resume."

Impact. The precise consequences of this error were not determined, but presumably all configuration information, alerts, informational messages, and data collection summary data from the previous session are lost, and the system is reinitialized as if for a new test. At a minimum, this would cause an inconvenient time delay while the operator reconfigures the system.

Comment/Suggestion. Selection of the "New" option should return a strong warning and cause the operator to perform an intermediate step to ensure that "Resume" was not the desired option.

k. "RUNTIME SYSTEM" screen.

(1) Misreferenced. This screen is referred to in the operator's manual as a menu screen. Its basic function, however, is to provide information rather than to provide options.

Impact: The student may be confused by the fact that this "menu" is not a menu.

Comment/Suggestion: The screen should be referred to as a display rather than a menu.

(2) Runtime system clock. During data collection, the monitor keeps track of the amount of time elapsed since the last system initialization. This clock is labeled "TEST TIME," the meaning of which may not be immediately apparent to the student or operator, and which is a misnomer if the system has been reinitialized since the beginning of the test (a likely event during the current test).

Impact: The usefulness of the clock is diminished.

Comment/Suggestion: It may be useful for several reasons to allow the operator to modify the clock from the keyboard: (a) The times at various DCS sites could be easily coordinated through time hacks; (b) the clock could be used by the operator to time various test events; (c) the clock could be reset to reflect cumulative times even if the system has been reinitialized during the test. Furthermore, it might be useful if two such clocks were available (perhaps occupying the same screen space via a toggle): One could be used as a timer, as mentioned, while the other is cumulating run time. Also, the name of the clock should be changed (see finding 2.4.3.3 p. (2)).

(3) Runtime system message rates. "MSG RATE" and "TOTAL MSG RATE" on the RUNTIME SYSTEM screen are given with two decimal places.

Impact: Unnecessary precision. Screen clutter (see also finding 2.4.3.3 m.).

Comment/Suggestion: Show as whole numbers. One operator raised the question, Of what operational importance is the total message rate? He could not think of any possible use for the information. If the information is indeed of value, then operator training and system documentation should inform operators of its purpose and importance; if not, it should be removed. Would message rate during specifiable intervals be of greater or additional value?

(4) Runtime system active-channel indicator. The far right column on the screen presents a column of channel numbers. The active channels are highlighted. The label "CHN" above this column does not indicate the purpose of the column.

Impact: The student must overcome the inadequacy of the column heading.

Comment/Suggestion: Short of revising the whole screen, the column heading could be changed to "ACT CHN," meaning "active channels" (with the first abbreviation placed over the second in the column heading).

1. Alerts.

(1) Presentation of alerts. The "alert" line at the bottom of the CRT continues to flash messages (some informational, others bona fide alerts) until the operator manually cancels the message. New messages overwrite previous ones. Operators were frequently observed operating for long periods of time (e.g., all day) with an uncancelled message flashing. Alerts are not accompanied by audible signals.

Impact: Because the operator is not forced to act upon alert messages (such as "TAPE NOT MOUNTED, NOT MOUNTED CORRECTLY, OR RED BUTTON NOT PRESSED. S: 7471700"), a message may continue to flash indefinitely. Incoming messages, which overwrite the flashing message, may therefore go unnoticed and may be overwritten themselves by yet newer alerts.

Comment/Suggestion: All alerts should be presented in a manner that will necessarily attract the attention of the operator and require appropriate operator action. They should be distinguishable from informational messages. An audible (but not loud) alert tone should be considered. The current method of presentation could be improved significantly by the addition of a contrasting block of space in the alert line that indicates that previous alerts that have not been manually cleared by the operator have been stored and are available for viewing. The block need contain no more than a flashing symbol that acts as a reminder, such as "*," "A", or the like, or possibly a numeral indicating the number of uncancelled alerts.

(2) Alert follow-up. Currently, alert messages are present with no prescribed action indicated for the operator. Many different alert messages are possible.

Impact: The operator may not know what action to take, if any, in the presence of some system alerts. The meaning of the alert may not be understood.

Comment/Suggestion: Each alert should force the operator to respond in some way with appropriate options available.

(3) Alert message content. Many different messages are possible, and some of them, owing to their technical content, may not be understood by the operators. The alerts are not documented.

Impact: Without complete documentation of alerts, including their meaning and prescribed action, the operator may not be able to take appropriate action.

Comment/Suggestion: Each alert message should be accompanied by an identifying number that can be referenced in the operator's manual. The documentation should prescribe appropriate operator action for each message. Highly technical alerts could be

presented on the operator's display as a reference number only. No information should be presented on the display that is not understood by the operator (such as "S: 7471700" in the message "TAPE NOT MOUNTED, NOT MOUNTED CORRECTLY, OR RED BUTTON NOT PRESSED. S; 7471700").

m. Screen clutter and message reports. Some of the screens are cluttered with unnecessary verbiage. One example is the "MESSAGE REPORTS" screen as described in the operator's manual. The screen contains the following lines:

```
                        MESSAGE REPORTS
-------------------------------------------------------------
                  MESSAGE REPORT PARAMETERS

  ENTER STARTING TIME FOR REPORT ....  DD-MMM-YYYY    HH:MM:SS

  ENTER ENDING TIME FOR REPORT ......  DD-MMM-YYYY    HH:MM:SS

  ENTER CHANNELS FOR REPORT .........  ALL

  ENTER CLASSIFICATION CODE (1-4) ...  UNCLASSIFIED

    (1-UNCLASSIFIED, 2-CLASSIFIED, 3-SECRET, 4-TOP SECRET
-------------------------------------------------------------
```

The word "message" appears twice. The word "report(s)" appears five times (not including an additional occurrence on the "virtual" function key line not shown here). The word "enter appears four times.

Impact: Screen clutter requires longer reading time and causes the screen to loose distinctiveness: The intent of the screen may be less clear; any options on the screen may be less distinguishable from one another; and the screen may be less distinguishable from other screens. The net result is increased operational and training difficulties.

Comment/Suggestion: All screens should be reviewed for unnecessary clutter and revised accordingly. The example shown could be revised as follows:

MESSAGE REPORT DEFINITION

CURRENT TIME IS: HH:MM:SS

START TIME: DD MMM YY HH MM SS

STOP TIME: DD MMM YY HH MM SS

CHANNELS: ALL 1 2 3 4 5 6 7 8

CLASSIFICATION CODE: UNCLASSIFIED
CONFIDENTIAL
SECRET
TOP SECRET

The cursor should jump to the appropriate positions for date and time. Start time should default to the date and time of the first message logged since start-up. Stop time should default to the current date and time. Channels should default to ALL (other choices selected by highlighting with arrow key and space bar or return key). Classification should default to "unclassified" (others chosen by highlighting or by toggling [not shown]). Variations on this general approach are, of course, possible. Note inclusion of current time for operator's reference.

n. "EDIT WHICH CHANNELS?" procedure. The operator is unnecessarily required to have learned and remembered the proper response format.

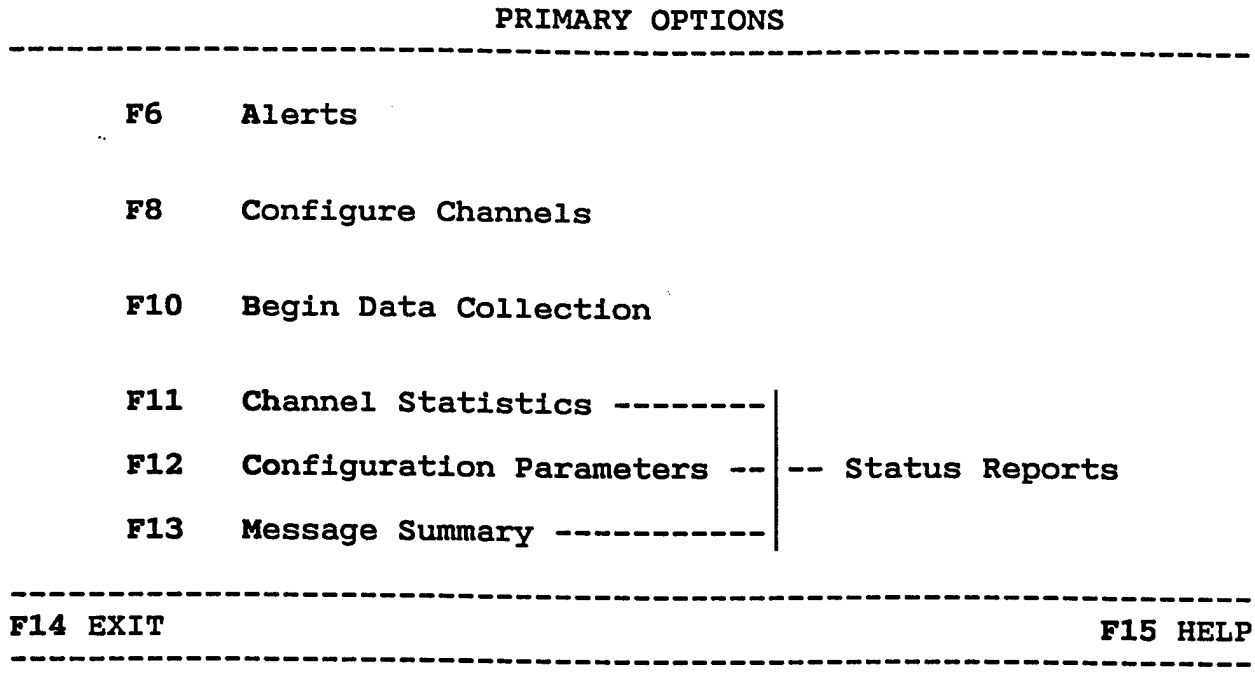
Impact: This shortcoming constitutes an easily avoidable cognitive requirement placed upon the student and operator.

Comment/Suggestion: It is unnecessary (and inconsistent with other procedures) to require the operator to generate a response and a format at this point. The possible response options could easily be presented in a small menu from which the operator could choose the appropriate items.

o. Conceptual complexity (menus). The operator interface, while simple enough in many ways, is to some extent unnecessarily complicated by subdividing primary options into two separate menus. Thus, the UTILITIES option on the current MODE SELECTION screen calls forth a sub-menu, the UTILITIES SYSTEM screen, containing additional selections that could be presented on the parent screen. Adequate room is available on the parent screen, especially if the "virtual function keys" were removed (as they should be; see finding 2.4.3.3 f.).

Impact: The operator's conceptual picture of the overall system and the way it operates is made unnecessarily complex. System operations tend to be harder to learn, slower to perform, and more prone to operator error.

Comment/Suggestion: The following is suggested as one possible alternative to the currently separate MODE SELECTION and UTILITY SYSTEM screens:



The screen would appear with the first alternative, **Alerts**, highlighted; at which point the operator could select **Alerts** in any of three ways: by pressing the F6 key, by pressing the bolded "a" key, or by pressing the return key. Similarly, other menu items could be chosen by pressing the associated function key, the bolded letter or letters, or by using the arrow keys to highlight the selection and then pressing the return key. (Particular items in menus can be grayed whenever they may be temporarily unavailable as choices.)

The advisability of categorizing operation options and then presenting each category in a separate selection menu is dependent on a number of factors, among which the following three are especially relevant here: (a) the conceptual relation among the categories; (b) the amount of available screen space; and (c) the speed with which the screen management software presents the screens. If categories exhibit dependencies, and screen space is at a premium, and speed is fast, then separate presentations tend to be more justifiable. On the other hand, the extent to which categories and the items within them are parallel, and the

greater the amount of available screen space, and the slower the processor, the less the advantage in separate menus.

In the C3I2 system, the primary operating options can be considered parallel (existing dependencies can be shown on the same screen, as for the Status Reports shown in the illustration above), screen rewrites are quite slow, and ample screen space is available.

Combining the current MODE SELECTION and UTILITY SYSTEM screens would, of course, have ramifications for the design of other related screens.

p. Conceptual complexity (terminology). The terminology used to name and describe the operations, processes, menus, and other system components is sometimes enigmatic, inconsistent, overused, easily confused, or easily forgotten--especially for the newcomer. For example, the terms "MODE" (as in "MODE SELECTION") and "SYSTEM" (as in "UTILITY SYSTEM") tend to complicate rather than simplify matters conceptually for the operator. Detailed examples and discussions are provided in subparagraphs 2.4.3.3 (1)-(16).

Impact: Teaching system operations to new students is made more difficult. Student retention of learned information is less stable. The subtle confusions that may result from the inadvertently careless use of terminology contribute to operator error and system failure.

Comment/Suggestion: Persons who have had a long-time relationship with a system tend to be insufficiently appreciative of the extent to which "everything is new" to the naive observer, student, or operator. The terminology used to describe a system is an important factor contributing to the ease of learning and remembering system operations. The meaning of all labels, titles, and the like, that are presented to a student or operator should be immediately apparent; they should not themselves constitute additional learning tasks. (There are, of course, situations in which physical space or other constraints require the coding of information into short or otherwise cryptic forms that must be learned by operators before they become useful guides.) The need to learn and remember special terminology in order to effectively operate a system should be minimized. Simple alternatives for such terms can often be substituted. (For example, "MODE SELECTION" and "UTILITY SYSTEM" could be replace by alternatives such as "OPTIONS," "SELECT ONE," or the like.) A conscious effort by hardware, software, and documentation developers must be exerted to overcome the inertia of their experience in order to create a user interface that will minimize learning problems, maximize learning and operational speed, and maximize the retention of knowledge and skills.

(1) "System." The term "system" is overused because the developer tends to present the system (i.e., the C3I2 system) to

the operator and student as a collection of related systems rather than as a single system with several related functions. The term "system" appears in the following: "C3I2 System" (the system); "Data Collection System," or "DCS," and "Data Reduction System," or "DRS," (two physically and functionally separate system components requiring different operators); "RUN SYSTEM" (the command to start data collection within the DCS); "RUNTIME SYSTEM" and "Runtime Subsystem" (both used to refer to the DCS data collection function); "UTILITY SYSTEM" and "Utility Subsystem" (both used to refer to a small collection of functions providing operational status information); "SYSTEM QUEUE" (one of several sets of notices, or "alerts," that reveal operational problems); "operating system" (which, according to the operator's manual, refers to both "overall system operations" and the computer's software "operating system" (VMS); and in the boot-up message "System logged out" (referring, not to the C3I2 Data Collection system, but to lower level software).

Impact: The inexperienced student operator may find it difficult to conceptualize the C3I2 system (the manner in which its components are related), and the resultant operating skill level may be lower than necessary. The greater the complexity of any system, or the inadequacy of the system-user interface, the greater the tendency for the operator to learn little more than that necessary to make the system work at a minimal level.

Comment/Suggestion: The terms "Data Collection System" and "Data Reduction System" can be tolerated because they describe very discrete aspects of the overall system; however, they would be better described as "components," "facilities," "elements," "modules," "sections," or the like, rather than "systems." Other simple changes would also help to clarify the conceptual portrayal of the system. Examples: (a) The command "RUN SYSTEM" (an option on the MODE SELECTION menu) should be something like "COLLECT DATA" or "BEGIN DATA COLLECTION," both of which more accurately reflect actual functionality; (b) an alternative for "RUNTIME SYSTEM" (the name of the data collection display screen) could be "DATA COLLECTION" or the like; (c) "RUNTIME SETUP" could be "DATA COLLECTION SETUP"; (d) "UTILITY SYSTEM" could be simply "UTILITIES"; (e) "SYSTEM QUEUE" could be changed to "COMPUTER," "GENERAL," or other term that accurately reflects the meaning of this alert category.

(2) "TEST TIME." This heading, which appears on the RUNTIME SYSTEM screen, is not necessarily indicative of the time shown. If the operator reinitializes the system, either accidentally or purposefully, the time will not be cumulative since the beginning of the test. (See also finding 2.4.3.3 k. (2).)

Impact: Interpretation of the time shown is ambiguous.

Comment/Suggestion: A term like "CUM(ulative) RUN TIME" would be less confusing because it would imply duration of the current run.

(3) "Queue." This term, as in "ALERT QUEUES," "SYSTEM QUEUE," "HARDWARE QUEUE," "SOFTWARE QUEUE," "CHANNEL QUEUE," and MISC QUEUE" may be new to most student operators.

Impact: It constitutes a small, nonfunctional obstacle that the student must work around. It detracts from understanding and does not elucidate operations. It clutters the ALERT QUEUES menu screen.

Comment/Suggestion: The term does not significantly improve understanding and should be dropped. The so-called "alert queues" could be simply referred to as "alerts."

(4) "Runtime." This term, which appears in "RUNTIME SETUP" and "RUNTIME SYSTEM," is not inherently meaningful.

Impact: The student operator must learn and remember that its meaning is simply "data collection," an unnecessary requirement.

Comment/Suggestion: The term should be abandoned and replaced by "DATA COLLECTION."

(5) "Self Test Utility." The self test is not a part of the "utility system," as one might expect on the basis of the terminology.

Impact: Additional confusion for the student or operator.

Comment/Suggestion: Drop the use of "utility" in connection with the self test. Refer to the self test simply as the "self test."

(6) "Mode." The term is used in "MODE SELECTION," which refers to primary operational options available to the operator in preparing for data collection.

Impact: The word "mode" complicates the student's picture of the system by suggesting one must enter different "modes" of operation to accomplish different objectives.

Comment/Suggestion: A simpler approach is to treat the alternative menu items simply as alternative choices--as shown in the sample screen (PRIMARY OPTIONS) depicted above (finding 2.4.3.3 o.) It is possible that the "mode" concept was useful during system development. It is not useful to the operator.

(7) "Exedir." The operator must type in the mysterious term "exedir" during start-up procedures (finding 2.4.3.3 a.).

Impact: Not only is the term unmeaningful to the operator, it should be unnecessary to enter any command at all at this point in the procedures.

Comment/Suggestion: The term "exedir" derives from "directory of executable files" and was handy for programmers involved in developing the system software. It should not be required of the operator.

(8) "Top-level." This term, which appears in the operator's manual to refer to initial menu options, is not a term well known to the layman.

Impact: A learning obstacle.

Comment/Suggestion: Either define it when first used or replace it with terms like "main," "primary," "initial," and so on.

(9) "DATA COLLECTION SYSTEM" menu. This main menu, which appears after the system is booted, is not well named. The menu does not list all primary components of the so-called data collection "system." What is more, the operator has, just prior to receiving this menu, been informed by the "system" that the "system" has "logged out" (finding 2.4.3.3. a.).

Impact: The operator is mislead about the meaning of the term "system." (See finding 2.4.3.3 p. (1).)

Comment/Suggestion: Retitle the menu "MAIN MENU."

(10) "Front end processors." This term, which appears in screen menu items and in the operator's manual is not defined and is not meaningful to computer illiterate persons.

Impact: Lack of understanding or confusion about the purpose and functioning of certain operational options.

Comment/Suggestion: Replace with an innocuous but meaningful term such as "data collection processor" or other appropriate lay designation.

(11) "PARMS," "PARAMS," "parameters," & "parameterization." The first two both appear as abbreviations for "parameters." The terms are not defined.

Impact: Some operators will have to learn the terms or follow instructions without a clear understanding of their meaning.

Comment/Suggestion: While "parameter" is familiar enough to persons with technical or professional backgrounds, it may be new to the C3I2 operator. Neither of the two abbreviations is desirable if avoidable; if used, "PARAMS" is preferred to "PARMS." "Parameterization" should be avoided, as in "CHANNEL PARAMETERIZATION MENU," which, because it appears in response to selecting the "CONFIG CHANS" option on the MODE SELECTION menu, could be re-entitled "CHANNEL CONFIGURATION MENU."

(12) "SEE PARMS" & "SHOW PARAMETERS." The INPUT/EDIT PARAMETERS menu presents the option "SEE PARMS," which produces a screen entitled "SHOW PARAMETERS." The terminology is inconsistent, and the word "show" is inappropriate.

Impact: Operator confusion.

Comment/Suggestion: "SEE PARMS" should be "REVIEW PARAMS" (if the "virtual" function keys are retained on the screen), and "SHOW PARAMETERS" should be simply "PARAMETERS" or "CURRENT PARAMETERS," or the like.

(13) "RESULTS FROM TEST ALL CHANNELS." This is the title of a screen that may appear after the self test is conducted. The wording is awkward.

Impact: Meaning may not be immediately apparent to the student or operator.

Comment/Suggestion: Better wordings would be: "RESULTS FROM ALL-CHANNEL TEST," "RESULTS: ALL-CHANNEL TEST," "ALL-CHANNEL TEST RESULTS," or the like.

(14) "PREV SCREEN." This command is unnecessarily cryptic.

Impact: Possible misunderstanding as "preview screen" rather than "previous screen."

Comment/Suggestion: Change to "PRIOR SCREEN."

(15) Menu headings & screen generating commands. Some of the screen menus have unnecessary dual headings. Examples are: "REVIEW CONFIGURATION" (subheading: "CURRENT ACTIVE CHANNEL CONFIGURATION"); "REVIEW STATISTICS" (subheading: "CURRENT CHANNEL STATISTICS"); "MESSAGE REPORTS" (subheading: "MESSAGE REPORT PARAMETERS"). The subheadings tend to be redundant and somewhat inconsistent with the primary headings. The commands (options) selected by the operator to produce these screens are often semantically inconsistent with the screen titles they produce. Examples: The command (option) REVIEW CONFIG produces a screen called "REVIEW CONFIGURATION," which should be "CONFIGURATION REVIEW"; the command (option) "CHANNEL STATS" produces the screen "REVIEW STATISTICS," which should be "CHANNEL STATISTICS"; the command (option) "MESSAGE REPORTS" produces "MESSAGE REPORTS," which shows, not message reports, but message report parameters and, therefore, should be entitled "MESSAGE REPORT PARAMETER SELECTION" (an extension of the screen's subtitle, which is "MESSAGE REPORT PARAMETERS") or, perhaps better, "MESSAGE REPORT DEFINITION"; the command (option) "MAKE REPORT" produces "REVIEW REPORT," which should be "MESSAGE REPORT."

Impact: Student and operator confusion.

Comment/Suggestion: The information provided by the dual headings would be more effectively presented in single, logical headings that correspond semantically to the commands, or menu options, that generate them.

(16) "START OVER" (F10). The meaning of this option, which is presented on the MESSAGE REPORTS screen, may not be clear to the operator because what is to be restarted is not clearly indicated.

Impact: The operator may wonder how far back into the procedures the function will loop and, consequently, may hesitate to use the feature when it would be appropriate.

Comment/Suggestion: The option should be given a more informative name that indicates "reset message report parameters to default values." Of course, the "virtual" functions keys do not allow room for more than two groups of seven characters each to describe any given function--another reason for abandoning this cumbersome screen index.

q. Operator errors resulting from software interface.

(1) Accidental reinitialization. Accidental rebooting of the system is too easy. If EXIT (F14) is selected from the RUNTIME SYSTEM screen (either accidentally or purposefully), the operator cannot return to the screen without the front-end processors being reinitialized. No warning is given to the operator.

a. One recorded instance occurred at DCS-2 at approximately 1500, 30 Jan. The operator reported that the system did not did provide sufficient warning when he "press the wrong key."

b. In another instance a system engineer reported that he had accidentally shut down the system when coming out of the quick-look procedure before he realized what was happening; he did not know what exact sequence of steps produced the result.

c. A third instance (1625, 1 Feb) appears to be related to the second. The operator reported that the following sequence of events produced reinitialization: (1) In RUNTIME SYSTEM; (2) Pressed F13 UTILITIES; (3) Chose ALERT QUEUES from UTILITY SYSTEM menu; (4) Received AITG ALERT; (5) Pressed F14 EXIT; (6) In UTILITY SYSTEM menu; (7) Pressed F14 EXIT; (8) In MODE SELECTION menu; (9) Should have pressed F14 to return to RUNTIME SYSTEM, but thought he pressed a different key (?) by mistake, which reactivated the front end processors without warning.

Impact: Accidental reinitialization may not reactivate all of the channels, and obviously, involves the possible loss of important test data. It is unacceptable.

Comment/Suggestion: Reinitialization or shutdown of the system should be possible only after the operator (a) has been strongly warned of the consequences and (b) has been required to perform an operational step that is sufficiently dissimilar to all other procedures to minimize the possibility of pressing inappropriate keys out of habit.

(2) Zero vs. the letter "O." The operator, attempting to follow instructions in the documentation for a diagnostic test, typed the letter instead of the number. The documentation showed the number zero without a hash mark; the operator read it as the letter "O."

Impact: The operator was unable to perform the desired test.

Comment/Suggestion: The distinction between Ø and O should be clearly indicated in the operator's documentation by including the hash mark across the number.

2.4.3.4 Human factors (operator hardware interface). The following list presents the human factors findings to date that pertain to the C3I2 prototype hardware:

a. M-880 truck with shelter. Operators reported that the center of gravity is shifted to the rear because of the weight of the S-710/M shelter and its equipment and that at 55-60 mph the vehicle is unstable on uneven roads. They stated that the shelter's weight appears to be unevenly distributed, with more on the curbside, which might contribute to the shelter's tendency to "rock" during movement and during operations when the wind is high. They also noted that the effect seems to be greater without the M101A2 generator trailer attached.

Impact: Operators felt that the instability of the vehicle could create lack of mobility or even constitute a safety hazard in the field. One operator reported that he had (at Fort Hood, prior to the test) experienced queasiness while operating on a windy day.

Comment/Suggestion: A determination needs to be made regarding the adequacy of the current configuration both from a standpoint of safety and mobility. Operators suggested that the shelter needs to have some sort of stabilization device to prevent it from rocking in the wind during operations.

b. Power generator. According to the system developer, the generator engine is known to have the tendency to run rich after several days (50 hours) of operation. The spark plugs in the two center cylinders, which are closest to the center of the intake manifold, tend to get fouled. When this occurred during the test, replacement plugs were not immediately available.

Impact: Power source becomes unreliable. The two spark plugs must be changed.

Comment/Suggestion: Extra plugs should be carried with the system at all times.

c. GOES antenna. The turn screw for locking the antenna mount in position is not captive.

Impact: The screw could be lost, especially during vehicle movement, when it could vibrate loose if not tightened down.

Comment/Suggestion: All operated screws, pins, locks, tie downs, and the like should be captive to prevent accidental loss. (The GOES antenna itself is normally stowed safely during movement.)

d. GOES antenna lead wire. The wire is strung loosely over the top of the shelter from the antenna to the connector on the side of the shelter.

Impact: The ample slack in the wire would allow a brisk wind (less than 35 mph) to blow the wire off the shelter top and down across the back of the shelter and the shelter door. Although perhaps unlikely, the wire could be damaged by the opening and closing of the door, especially if it were to fall between the hinge edge of the door and the outside shelter wall when the door is open.

Comment/Suggestion: Although the presence of the curbside receive/transmit antenna mast, when it is mounted, would help to keep the GOES antenna wire on the roof of the shelter. An additional helpful measure would be to attach a guy device atop the shelter near the rear curbside corner where the wire could be secured. An interim substitute for the latter procedure would be to tie off the slack at the handhold located topside.

e. Exterior shelter junction box. Some of the Velcro strips that hold the canvas flaps in place when the cover is raised are beginning to come loose.

Impact: The flaps are seldom used, but there may be times during which they should be used, as during certain severe weather conditions. Without effective fasteners the flaps will not be used.

Comment/Suggestion: Replace loose strips.

f. Padlock retaining chains. There are two padlock chains on each of the two exterior storage compartments doors. Each of the four chains forms a stiff, three- or four-inch loop that protrudes approximately two inches outward from the widest part of the vehicle.

Impact: The chains are very vulnerable to catching on brush or other objects that might be encountered in tight situations.

Comment/Suggestion: The retaining screw for each chain needs to be relocated so that while the padlocks are in place the chains are situated horizontally in a straight line, allowing only sufficient slack to permit installation and removal of the padlocks.

g. Shelter door (ladder hanger). On the inside of the door is a hanger that is no longer used or needed.

Impact: Probably minimal; but it could catch on clothing or otherwise get in the way.

Comment/Suggestion: The ladder is now stowed in the generator trailer; therefore, the door hanger should be removed.

h. Tie-downs. Rubber straps are provided as tie downs for equipment during vehicle movement. Within the shelter they are used to secure such items as the CRT monitor and keyboard, the operator chairs, a tool case, and a first aid kit. In the generator trailer, they are used to restrain extra fuel cans and other equipment. One operator reported an occasion in which one of the straps broke during application.

Impact: The straps provide an interim solution for securing equipment, but they are awkward to install and possibly unreliable. Because they are not customized for specific applications, they require the operator to decide where and how to attach them--there is no prescribed way. They may be lost or misplaced and constitute a supply requirement. The item most at risk is the CRT monitor.

Comment/Suggestion: The CRT shelf should provide secure attachments (e.g., hasps, or other easily operated connectors) for the CRT. Each item of equipment requiring stowing and unstowing and which is subject to damage (or which may damage other equipment) during movement should be provided customized stowage with built-in, easily-operated mechanisms for securing and unsecuring.

i. Cabling. Installation cables are currently identified by labeling and referenced in diagrams. One technician noted that a useful addition to the system would be the visual coding of installation cables, which would allow visual tracing at a glance.

Impact: Maintenance time is increased and made more difficult if cable tracing is problematical. Wire bundles may have to be unwrapped or a continuity test performed to locate related cable connectors.

Comment/Suggestion: If it is not possible to trace visually the entire length of an individual cable, it would be helpful if the cable ends were similarly marked and distinguishable from the markings of other cables in the vicinity. This would provide a

means for easily relating the two ends of a given cable, especially when the cable is bundled or intertwined with others or located in a cramped or dimly lit location. Identically coded collars with patterns and bright colors could be placed adjacent to the connector at both ends of a cable. (The system developer notes that some of the cables are interchangeable, which might preclude using specific plug-to-jack coding.)

j. Air conditioner. The air conditioner is quite noisy but does not seem to bother operators who report having adapted to the noise so that they are normally unaware of its presence.

Impact: Minimal negative impact.

Comment/Suggestion: There are three fan speeds. The system developer reports that the lowest speed is about 3dBA lower in radiated sound level than the highest and that part of the noise emanates from air flow over EMI filters in the louvre areas. The developer also states that a quieter unit could be substituted if desired.

k. Air conditioner switch labeling. The meaning of the term "condition" on the VENT/OFF/CONDITION switch is unclear. When one operator was asked to explain the label, he could not. He only knew that he was supposed to put it in the "condition" position.

Impact: Operators may not be able to make maximal use of the air conditioner.

Comment/Suggestion: Does "condition" mean "recirculate"? Does it apply to both HEAT and COOL? Clarify by relabeling.

l. Emergency light labeling. The meaning of the labeling is not clear. On the side of the "Enable/Disable" switch box is an LED with a test switch. The LED, which is normally on, is labeled "CHARGE MONITOR," which to the uninitiated could mean either "charge the monitor" or "monitor the charge." The test switch, labeled "PRESS TO TEST," is a toggle that must be pushed down rather than in, as the label would seem to imply. When the test switch was tried, nothing happened.

Impact: Student and operator confusion. Some operators may have to be told what the "CHARGE MONITOR" label means. The LED, normally on, is apparently meant to signal a problem when it is not on, but then it would probably not be noticed.

Comment/Suggestion: (a) The meaning of labeling should be self-evident and, if avoidable, not constitute another learning hurdle, however small. (b) Either the operation of the LED should be reversed, which might cause electronic complications, or additional labeling should be added to indicate its purpose clearly. (c) Operation of the emergency light should be covered in system documentation. The operator should not encounter a

situation in which the test switch is tried with no response from the system unless the switch is accompanied by instructions indicating when such an occurrence is normal.

m. Ceiling lights. The fluorescent ceiling lights inside the shelter are reflected from the oscilloscope windows directly into the operators eyes.

Impact: It is quite difficult for the operator to read the oscilloscopes without holding a hand up to shade the eyes from the glare.

Comment/Suggestion: Moving the location of the scopes, as suggested elsewhere (see finding 2.4.3.4 r.) would solve this problem.

n. Printer location. The current location of the printer (directly across the shelter isle from the operator's console) may not be ideal. It occupies the space most logically suited for operator writing, referencing of manuals, and so on. Furthermore, the current orientation of the printer (front of printer toward isle) leaves less than a page length of space behind it for continuous paper to feed and accumulate.

Impact: (a) Having swiveled around (up to 90 degrees) to use the desk surface on the roadside of the isle, the operator must lean forward toward (or roll the operator's chair toward) the shelter access door to use the available desk surface. The problem would be exacerbated for the left-handed operator. (b) Accumulating paper does not stack appropriately behind the printer.

Comment/Suggestion: A better location and orientation for the printer may be the following: Place the printer so that it faces the front wall of the shelter, with its right side as close to the curbside of the shelter as possible while allowing sufficient hand space between the printer and the curbside wall. Set the back edge of the printer as close to the rear wall as possible while allowing sufficient space for the accumulation of continuous paper. While this places the printer farther from the operator, the disadvantage is minimal because the operator does not need frequent access to the printer. With the printer in this location, all of the desk surface closest to the operator becomes available for the operator's use. The desk surface would be accessible to the right-handed operator who swivels clockwise 90-180 degrees and to the left-handed operator who swivels clockwise 135-180 degrees.

o. Circuit breaker panel. This panel was examined in one of the DCS vans. The cover on the panel (curbside, bottom left of operator) has no labeling (the contents are not identified). The panel behind the cover contains four switch locations and three switches (one switch location is empty). One of the three switches (upper left corner) has no label, but is white in color as if to distinguish its function from the others, which are

black. The other two switches are labeled CB14 and CB15. The switch handle on CB15 is broken off. The empty switch hole is labeled CB16. The operator was able to find CB14 and CB15 on the AC wire diagram, but not CB16 or the white switch.

Impact: Whether or not the broken switch on CB15 could be manipulated with a tool such as a screwdriver is unknown. There was some confusion about the purpose of the CB16 label--was there a switch missing? Even if operators were trained in the use of this panel (apparently they were not), the absence of informative labeling would make it difficult to remember the switch functions because of their infrequent use.

Comment/Suggestion: Include informative labeling on both the cover and the switches. If the white color of the unlabeled switch is significant, so indicate; if not, ensure that like switches have the same color. Fix the broken switch.

p. A.C. Power/generator monitor/control panel dials. The dials on the left side of this panel, which monitor "INPUT POWER" and "U.P.S. POWER" have what are, seemingly, strips of green colored paper pasted above the scales to indicate normal (or acceptable) ranges. The colored strips are crudely made (apparently, by hand) and are beginning to buckle and peel off on three of the five dials (checked in DCS-2 only). On the top two dials ("A.C. VOLTS" for "INPUT POWER" & "U.P.S. POWER"), the strips have red colored bands at either end of the strips to indicate danger (or unacceptable) ranges. The green and red colors are not highly saturated.

Impact: Besides being of questionable durability, the strips are not colored adequately. The red-green color deficient person may be unable to distinguish either the read or the green and, more important, be unable to distinguish the red from the green. Both of these effects were, in fact, observed in one such person.

Comment/Suggestion: The strips should be redone so that they are durable and are colored to maximize the distinguishability between the green and the red.

q. Uninterruptible power system dials. The two dials ("AC VOLTS" & "DC VOLTS") on the U.P.S. unit (bottom unit in power rack) have poor viewing angles. While the operator can see the position of the needles, the scales above them are not in view from the normal operating position.

Impact: In this system, minimal.

Comment/Suggestion: This is a common manufacturing "defect" that prevents easy reading of the dials unless the viewer is positioned rather directly in front of the dial windows. The actual dials are inset behind the windows so that the window frame cuts off the viewing angle. The only recourse for the user

is to position the equipment where operators can see the dials easily.

r. Panel equipment positioning. The relative locations of the GOES antenna readout (N.B.S. time), modem, speaker bank, and oscilloscope bank are not optimal. The present configuration puts the often-viewed oscilloscopes at the top of the rack, high above the operator's eye level.

Impact: Although the operators did not complain about the current configuration, they were observed to constantly strain their necks upward. For operators with bifocal lenses (one operator wore bifocals), this could be troublesome during sustained operations.

Comment/Suggestion: The ideal order would put the speaker rack at the top because it does not need to be viewed by the operator. Next should come the satellite time readout (GOES), which does not have to be viewed with great frequency. The oscilloscopes should be third down in the rack because the operator frequently refers to them. The most frequent reference point above the CRT monitor is the modem panel; therefore, it should be as low as possible without obstructing the view of the CRT. According to the system developer, there is no system constraint that would make reordering these items unadvisable; therefore, they should be reordered.

s. Modem panel. The most frequently referred to rows of LEDs are at the top of the panel. The least frequently viewed rows are at the bottom.

Impact: The operator must look higher for the more frequently needed references.

Comment/Suggestion: Though not of drastic importance, the ideal ordering of the LED rows would put the least often viewed at the top and the most often viewed at the bottom.

t. Keyboard & shelf. The keyboard is too wide for its sliding shelf; it overlaps at both ends. The keyboard contains many keys that are never used by the operator (e.g., the "Help" key). (The entire right-hand bank of 18 keys is not used.)

Impact: Because of its width (required by the unused keys), the keyboard cannot be stowed either on its pull out shelf or on the monitor shelf during system transport. Operators may wonder, for example, why the "Help" key (in the F15 position) is not used for the HELP option.

Comment/Suggestion: A narrower keyboard would be much better, both from the standpoint of physical size and operator usage. A smaller keyboard would also allow the incorporation of an additional feature: Another sliding shelf could be installed just above the current keyboard shelf. The shelf on which the

monitor now rests could be moved up enough to accommodate the new shelf without making the monitor too high. The new shelf would accept the keyboard, which would be clamped to it. It would be able, with the keyboard installed on it, to slide in beneath the monitor shelf. Because the keyboard is not used constantly, it could be slid into the stowed position much of the time, during which the current keyboard shelf would be available as an excellent writing surface or surface for reading manuals, or performing other duties.

u. Computer mount. The MicroVAX II computer is mounted in an equipment rack and bolted in place. The bolt holes in the mounting rack did not line up well with the frame of the computer.

Impact: On one occasion, the operators were observed having extreme difficulty mounting the computer. It was necessary to lift the heavy computer while attempting to insert the bolts at the same time.

Comment/Suggestion: The support contractor reported that the rack alignment was good prior to system transport and that a shift had occurred during transit. Apparently the racks are not constructed to completely resist the jolting and twisting motions accompanying normal system transport. The solution, according to the support contractor is to enlarge the holes in the mounting rack, which, reportedly, they could easily accomplish.

v. Computer cover panel. The top panel of the MicroVAX computer is secured by 36 screws. Using a high-speed hand-held drill, a technician required approximately 4.5 minutes to remove all screws and approximately 3.5 minutes to reinsert and tighten them. The front panel holds 10 screws, requiring about 1 minute to remove and 2 minutes to install.

Impact: The total labor time involved in removing and replacing both panels is about 11 minutes.

Comment/Suggestion: The process is quite time consuming. Can doctrine allow the use of fewer screws during non-secure operations? Are all the screws necessary, even for secure operations?

w. Computer access door. The computer access door, which should be closed during normal operations, displays no notice of the requirement to the operator. The operators were fairly conscientious about keeping the door closed. (See also finding 2.4.3.2 b. (6).)

Impact: Some operators might establish an undesirable, relaxed attitude toward the need (especially during secure operations) for keeping the door closed.

Comment/Suggestion: Both the inside and outside of the door should display an appropriate notice. Keeping the door closed not only allows secure operations, but helps to regulate computer temperature and to prevent the entrance of foreign objects into the compartment housing the disk drive and tape recorder.

x. Computer panel lock.

(1) Operating without computer lock engaged. One operator was observed operating without the computer's front panel lock engaged.

Impact: The panel buttons could be inadvertently pressed, which could halt operations and cause loss of mission data.

Comment/Suggestion: Operators must be reminded of the importance of disabling the panel buttons while operating. A warning to that effect should posted in a prominent location, such as on a list of important operational considerations placed high on the inside surface of the shelter door. (The operator remembered his oversight when another person leaned against the computer. He quickly obtained the key, which was not in the lock, and corrected the situation.)

(2) Computer lock is unlabeled. The lock has no accompanying labeling or instructions to indicate its purpose or how it functions.

Impact: The operator cannot tell by looking at the panel buttons whether they have been disabled or not. The only clue is the position of the keyhole, the significance of which the operator is forced to remember without the aid of labeling. If the operator is unsure of the proper direction in which to turn the key to disable the buttons, and the key is turned in the wrong direction, the computer will reboot, causing a possible loss of important data.

Comment/Suggestion: The lock and its functions should be clearly labeled. There is room for a label decal on the top surface of the computer panel just above the lock. The lock mechanism should have a detent that would proscribe moving the key into the "reboot" position accidentally.

y. Tape backup. There is no way at the data collection facility (DCS) for the operator to backup the original TK50 storage tapes.

Impact: There is a possibility that collected test data will be lost.

Comment/Suggestion: Normally, data collected onto the hard disk should be automatically copied (spooled) to the TK50 tape on a regular basis (as processor activity allows). The original data remain on the hard disk (unless there is a hard disk failure) and

reside there until the disk becomes full. When the disk becomes full, it begins to overwrite its oldest data, as necessary, to make room for new incoming data. If data should become unretrievable from the hard disk (for whatever reason), the TK50 tape is the only copy remaining until it is transferred to the data reduction facility (DRS) and copied into that system. Should the tape be damaged prior to analysis at the DRS, required test information may be unattainable. The Army should determine whether the probability of such a loss warrants including additional tape backup hardware in the DCS. The assessment of this probability would require knowledge of message traffic densities, how the tapes will be handled (the amount of time it will take to deliver tapes to the DRS, etc.), and so on. (See also finding 2.4.3.3 c.)

z. Utility drawers.

(1) Latch attachment. In one of the shelters the nut for the drawer retaining latch was found lying loose inside the drawer (rack 7R).

Impact: If the drawer latch on either of the two storage drawers were to fall off during system transport, the drawers would be free to slide violently in and out as the shelter sways or the vehicle negotiates turns or curves. While the drawers are retained so that they will not fall out of rack, their contents, which may include the console keyboard, could be jostled forcefully.

Comment/Suggestion: The latches are attached with a bolt, nut, and some spacers. Short of redesigning the latches (see (2), below), it should be determined that all nuts are of the locking type and securely in place

(2) Latch design. Gravity holds the latches in the locked position. The operator must turn the latch upward to allow the drawer to be opened. It can be turned only one way because of protruding screw heads on the drawer frame. When the drawer is pulled out, the latch is released and it falls back into the locked position so that it must be lifted again before the drawer can be closed and secured.

Impact: It requires two hands to open or close the drawer, one to hold the latch, one to move the drawer. It is not uncommon for the operator to forget that the latch must be lifted to close the drawer; in this case, the drawer is slammed against the latch, which, of course, reminds the operator to lift the latch.

Comment/Suggestion: Consider redesigning the drawer latches.

2.4.3.5 Safety hazards.

a. M-880 truck. See finding 2.4.3.4 a.

b. Halogen desk lamp. The 100 watt halogen lamp (ELECTRIX, Model 2V945) generates much heat, which, besides providing an additional burden for the air conditioner, constitutes a physical safety hazard for personnel and a possible fire hazard.

Impact: A person who sits on the shelf beneath the light (a natural place for an observer) may receive a burn, or clothing may be damaged. One such instance occurred prior to the test: A person seated on the shelf with his shoulder beneath the lamp was unaware that his jacket had started to smoke. He was warned by others, and no injury or serious destruction occurred.

Comment/Suggestion: The lamp should be removed, or replaced by a light source that presents no hazard.

c. Shelter entrance way. The low profile of the top of the door jam presents a constant threat to persons entering or leaving the shelter. One person receive a bleeding cut to the top of his head. Others reported hitting their heads.

Impact: Serious injury, though improbable, could occur. Minor injuries will occur from time to time in the life of the system.

Comment/Suggestion: This is a common complaint for shelters of this type. Whether or not it would be possible to retrofit the doorway in this shelter with some sort of padding was not determined. It may be unfeasible, for security reasons or because of physical constraints, to attach such padding to the jam itself. However, it may be possible to suspend a padded bar or the like from the shelter ceiling just inside the doorway. Such a bar would extend downward enough to cause persons entering or leaving to duck down a little farther than they do now and thus clear the door jam.

2.4.3.6 Health hazards. There are no known health hazards associated with operating or maintaining the C3I2 system.

2.4.4 Discussion. The number of MANPRINT findings presented in this report reflects more directly the detail of the analysis than the overall standing of the system with respect to MANPRINT concerns. Considering the prototype nature of the current system and the absence of "high drivers," such as time pressure on system operators, complex operational tasks, and the like, the system can in most respects be considered satisfactory, though not ideal, with regard to MANPRINT. Many of the lesser findings could be overlooked without great injury in the prototype, but some of them would take on greater importance in subsequent versions of the system. Furthermore, several of the findings were of major import even for the prototype system, and they require attention. It should be noted that the system developer has already implemented suggested changes in several areas and has begun implementation of others.

2.4.5 Conclusion. The following summarizes the most significant MANPRINT concerns for the prototype C3I2 system. They are listed in order of appearance in the Results section, not by priorities, which remain to be established.

2.4.5.1 The use of military operators may be more appropriate than the use of contracted technicians as operators. (Finding 2.4.3.1)

2.4.5.2 Extensive training time will not be required (probably less than a week). (Finding 2.4.3.2 a.)

2.4.5.3 Formal, separate training courses and system documentation need to be developed for operators and maintainers of the system. (Finding 2.4.3.2 b.)

2.4.5.4 The system needs an effective self test for determining that it is functioning properly both prior to and during data collection sessions. (Findings 2.4.3.3 b. & 2.4.3.3 h.)

2.4.5.5 The system must archive data on a regular basis, regardless of traffic density. (Finding 2.4.3.3 c.)

2.4.5.6 Alert messages may go unnoticed. (Finding 2.4.3.3 l. (1))

2.4.5.7 Conceptual complexity for the student could be reduced significantly in terms of screen presentation (general screen clutter, menu design, & system terminology). (Findings 2.4.3.3 m, o, & p.)

2.4.5.8 The system is too easily reinitialized accidentally, both via the keyboard and the computer panel key lock. (Findings 2.4.3.3 q. (1) & 2.4.3.4 x. (2))

2.4.5.9 The current location of the printer should be reexamined. (Finding 2.4.3.4 n.)

2.4.5.10 If data on a hard disk should become inaccessible, the TK50 tape would have no backup prior to input into the DRS. (Finding 2.4.3.4 y.)